

Design and Implementation of Node Based Electrical Power Measurement for Auto Billing

¹Sneha Atmaram Chautmol (M.E Student)

Pankaj Laddhad Institute of Technology

& Management Studies, Buldana

Email-id : snehachautmol@gmail.com

²Asst. Prof K.A.Dongre

Ram Meghe College of Engineering

& Management, Badnera, Amravati

Email-id: kirandongre2015@gmail.com

Department of Electrical Engineering

Abstract

Electricity is an important resource which should be utilized in an optimum manner. It must not be wasted. Automation has taken over the world in many aspects which has brought about many key benefits like reduction in manual labor, increased efficiency in work together combined with the benefits like timely work and reduced costs. One field that requires automation to bring about more advantages is the billing system of Electricity by supply boards of different cities be it in private or government companies. The proposed paper presents an efficient auto billing technique which combines the benefits of automation as well as increases the overall efficiency of the system. The technique uses Zigbee technology for node based communication. The meters need to be replaced with the new technology ones but shall be a new upgradation that shall remove the existing disadvantages.

Keywords: Zigbee, node, auto-billing, microcontroller.

Introduction

Energy meter readings are taken at every month cycle to charge the consumers according to their usage. Number of units that a consumer has

used is charged according to the area and rate per unit in the limits. At present a person is appointed to take a photo of the meter reading at every month from all the houses and then the same or different person distributes the generated bills at homes. The consumer is then required to visit the billing center to pay the bill or some electricity boards have provided the option of payment by e-wallets. In case of any problems faced by the consumer in terms of being over charged, wrong bill supplied or any other concerns related to non-accurate meter readings, the dispute needs to be solved by the consumer and electricity boards by personal meet-ups. The existing system for non-payment of bills causes a team to be sent to the consumers home and the line is switched off which does not allow the consumer to use electricity but some genuine cases can be considered or given some time by discussing the issues with the team. This can bring about the role of corruption. The teams can be prone to taking bribe to stop the line cuts. This billing section thus needs an efficient technique to automate this task of bill generation, providing bills to the users.

A smart energy meter is an electric device having an energy meter chip for consumed electric energy measurement, wireless protocol for data

communication (such as GSM Modem) and peripheral devices for security purpose, data showing, meter controlling etc.[4] In this system the reading is taken automatically and the consumer directly gets to know how much electricity has been used by him. The reason for selecting WSN (wireless sensor network) is WIDE range And communication through sensor network through mesh topology. By any means the data is transferred to the next level or meter by their connectivity network. The data is transferred to the office along with metering value and any other theft detected.

The new feature introduced in this system when any person tampers or tries to remove the box cover of the energy meter, it is detected by the sensor and the output of the comparator is set and fed to the microcontroller and also the magnetic sensing is provided and the system sends the message to the MSEB that theft for electricity is done. This feature shall prove useful in cases of power thefts by some consumers who in the lieu of reducing bills resort to new techniques of cheating the MSEB. This feature shall prove useful to reduce power thefts and thus provide an efficient node based auto-billing system.

II. Methodology

As we know that the technology of e-metering has gone through rapid technological advancement. There is increase in demand for reliable, accuracy and efficiency. So, by this project we introduce a design of simple low cost wireless "GSM based automatic energy meter reading system". The proposed system consists of digital energy meter, arduino nano, antitheft mechanism, GSM modem, relays and current

transformers. Here the connection of current transformer is at the input of the energy meter who works on the principle that the difference between incoming current and outgoing current is equal to zero and the connection of relay is at the output of energy meter for proper working. The proposed design intends to implement a system which can read the meter read the meter reading electronically and transfer it automatically through the Zigbee to the energy provider side for billing purpose.

Energy Measurement Methods

There are two main methods of energy measurement. These are

a. VI COS Φ Method

In VI COS Φ Method, the RMS value of voltage and current are found out over a Time period. The product of VRMS, IRMS and the power factor (cosΦ) gives the power. Energy consumed over a period is given by the product of power and the time interval.

$$\text{True power} = P$$

$$P = VI \cos \Phi$$

$$\text{R.M.S.} = V$$

$$\text{Voltage}$$

$$V = V_m / \sqrt{2}$$

$$\text{R.M.S. Current} = I$$

$$I = I_m / \sqrt{2}$$

$$\text{Power Factor} = \cos \Phi$$

$$\Phi = \tan^{-1}(\text{reactance/resistance})$$

$$\text{Energy} = \text{Power} \times t$$

b. Instantaneous Measurement method

In Instantaneous method, it is found that the power comes out be $VI \cos\Phi$ which is same as in $VI \cos\Phi$ method. So it automatically takes into In Instantaneous Energy measurement method, the AC mains voltage and current are sampled at same frequency. The instantaneous values of voltage and current are multiplied and the average of these instantaneous values over time period gives the power and integration with respect to time gives energy consumed.

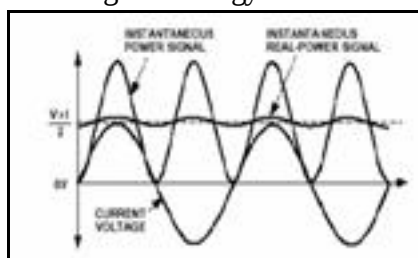


Figure. a: Waveform

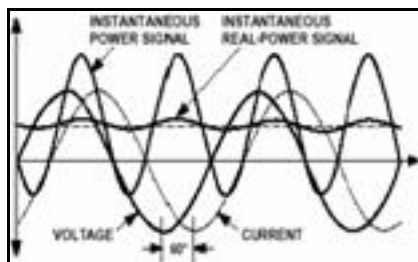


Figure b: Waveform

$$\begin{aligned} \text{Instantaneous Power} &= V_m \sin \omega t \times I_m \sin(\omega t - \Phi) \\ &= \frac{1}{2} V_m I_m [\cos \Phi - \cos(2\omega t - \Phi)] \\ \text{Power} &= \frac{1}{T} \int P dt \\ &= \frac{1}{2} V_m I_m \cos \Phi \\ &= V_m / \sqrt{2} \times I_m / \sqrt{2} \cos \Phi \\ &= VI \cos \Phi \end{aligned}$$

account the power factor. The advantages of instantaneous methods are

- 1) $\cos\Phi$ factor is removed effectively.
 - 2) Instantaneous method is applicable to any type of wave form whereas $VI \cos\Phi$ method is applicable for pure sine wave.
- So it is decided to use Instantaneous method to calculate energy consumed for which ASIC are available

Block Diagram

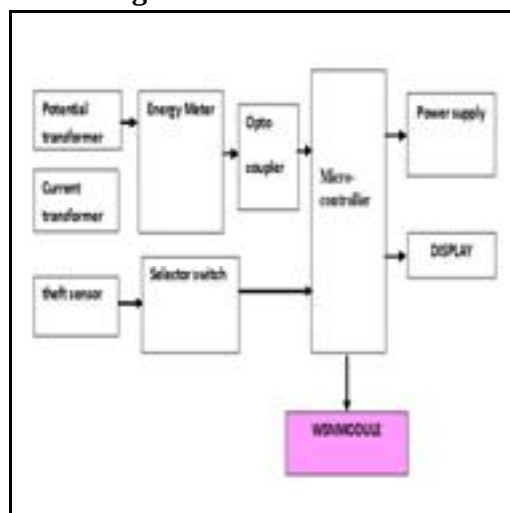


Figure: Block Diagram of The System

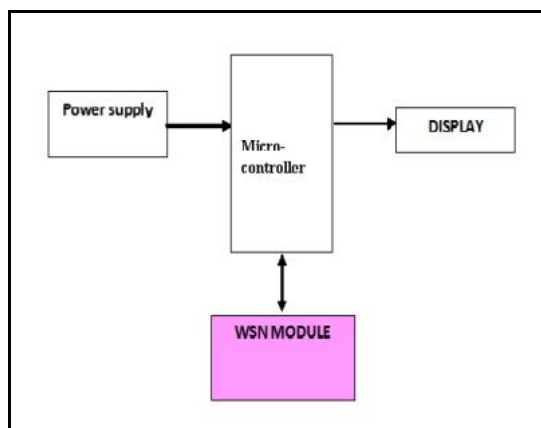


Figure : receiver node 1

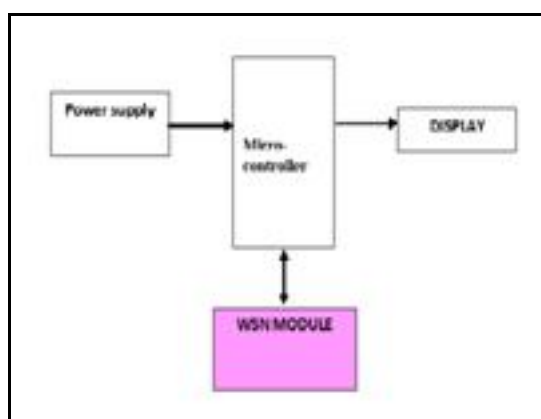


Figure : receiver node 2

ZigBee Module

ZigBee is one of the protocols developed for enhancing the feature of wireless sensor network. It is considered as a major achievement in the development of wireless network sensor. It is developed to fulfill the goal in wireless sensor that utilizes low power and low cost. This protocol is established by ZigBee Alliance, 2006 which is based on the IEEE 802.15.4.

It is a wireless networking technology which is used to transmit the data with high speed, Security, reliability & low cost [3].

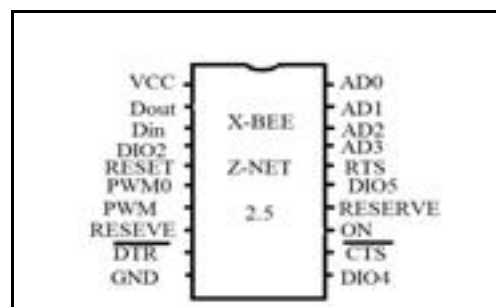


Fig Zigbee

The step down Potential transformer and Current Transformer are used to sense Voltage and current respectively. Output of Potential transformer and Current Transformer is given to AD7756, which is dedicated IC for energy measurement. The energy metering circuit is connected to the microcontroller. When the load is connected the energy consumed is measured and the value is in the form of pulses. These pulses are measured to generate the amount of energy used. The measure value of Energy will be displayed on the LCD display screen. Based on the measured value of Energy, Micro-controller continuously checks for the billing value and tampered situations. After every two months the present recorded value will be transmitted to M SEB. Micro-controller/PC will communicate with mobile/WSN card via IR port or serial cable. In case of any theft and tempering of the energy meter the signal is sent to the remote station. The supply to the load is disconnected and the data is sent to the M SEB indicating that the theft has happened. In the existing system by using zigbee we can get the information up to some distance.. It nearly covers single house. If we go for multiple houses like apartments or large size industries single zigbee can't cover that much distance. This is the main drawback present in existing system. To overcome the drawback present in existing system we are using zigbee

router. A wireless sensor network is a potential candidate for Building Area Network, and it has been widely adopted in industrial automation which transmitted the data over large areas using its multi-hopping ability. ZigBee is one of the well-known wireless sensor network standards, and it has been widely adopted in different projects as a result of its intrinsic mesh property, which provides good scalability and connectivity. One zigbee placed at one floor and other zigbee is at mseb. We can monitor the conditions in different floors through zigbee. If we want to control any devices also we can control from different floors. These zigbee's are connected through router so that we can monitor and control from different floors. The values can be monitored on display unit which is connected to micro controller. By using this zigbee router we can cover large areas. Here we are using 8 bit micro controller to implement this project. In this project, energy metering circuit is connected to the microcontroller, here when the load is connected the energy consumed is measured and the value is in the form of pulses. That pulses are measured to generate the amount of energy used. That value of unit consumed is shown on LCD. It is a 16*2 type back light intelligent lcd. Which is interfaced with microcontroller on P0. which is 8 bit data mode of interfacing. Power supply consists of step down transformer of 230 to 9 v centre tap. Centre tap full wave rectifier is used for rectification that is converting the ac to dc voltage. dc voltage is then filtered to get pure DC voltage. That is pure dc voltage is regulated using IC 7805. to get fixed voltage of 5v. that fixed voltage is operating voltage is given to the circuit. Crystal oscillator is used for generating

fixed frequency to operate the microcontroller. The crystal oscillator frequency is used for 11.0592 Mhz.

I. Hardware and software requirements

Hardware Description

1. Liquid Crystal Display

A Liquid crystal display are interfaced to arduino nano unit that are used to display the meter reading, date time, power factor, power status, total load used etc. LCD continuously displays the present date and time and consumer usage of power in terms of units. Every peak time the information regarding units is sent to the EB (ELECTRICITY BOARD) office the acknowledgement is shown in the LCD



Fig.3.1: LCD display

2. Energy meter:

An energy meter is a device that measures the amount of Electrical energy supplied to or consumed by home or building. The most commonly used energy meter is kilo watt hour meter. [3]. The instantaneous power is then integrated against time to give energy used by the consumers. The meters are classified into two basic categories, electromechanical and electronic. The energy consumption is calculated by using the output pulses of energy meter.



Fig:Energy Meter

ZigBee

It is a wireless networking technology which is used to transmit the data with high speed, Security, reliability & low cost [3].

Features

- High Performance Low Cost
- Indoor/Urban: up to 300' (100 m)
- Outdoor line-of-sight: up to 1 mile (1.6 km)
- Transmit Power Output: 100 mW (20 dBm) EIRP
- Receiver Sensitivity: -102 dBm
- RF Data Rate: 250,000 bps

SOFTWARE DESCRIPTION

As our project required involved the application of software, on consulting with our project guide we came to the conclusion that we shall use Embedded C for programming utilizing the Keil software. Use of embedded processors cars, mobile phones, medical equipment, aerospace systems etc is widespread. The applications of embedded C are exploited through the Keil software. Keil was founded in 1986 to market add on products for development tools provided by many of the silicon vendors. It soon became evident that there was a void in the market place that must be filled with quality software development tools. It was then that Keil introduced the first C compiler designed from the ground-up specifically for 8051.

IV.Design and Implementation

V.Results



Fig: Transmitter Model

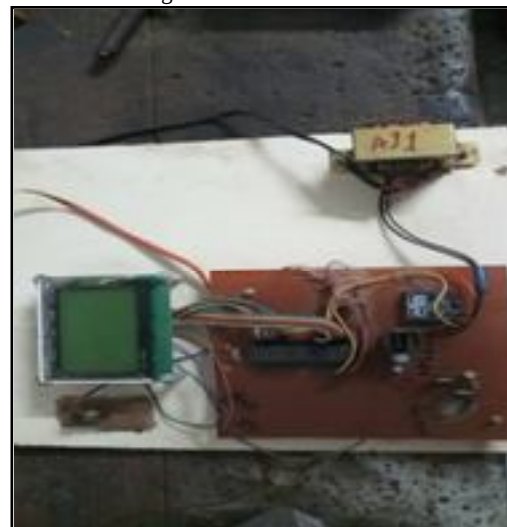


Fig: Receiver model

Conclusion

An efficient technique of node based auto-billing has been designed which can remove the disadvantages of existing

techniques of billing as well as the proposed techniques like gsm based smart energy meters which shall not be useful for a long term technological usage. Zigbee has been used for node based billing which removes the disadvantages of other communication modules.

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